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SYSTEM FOR RAPID HANDLING OF AN IRRADIATED SOLUTION

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ADMINISTRATIVE INFORMATION

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ABSTRACT

An apparatus has been constructed for rapidly transferring irradiated solutions to a container for fast radiochemical separations. A "rabbit" containing a solution is irradiated; within 1 second after irradiation it is transported through a pneumatic system to a receiver; there it impales itself onto two hypodermic needles connected to a container under vacuum. The irradiated solution and one acid wash of the rabbit are quantitatively transferred to the container within 2 seconds. Since the system is completely contained, there is no contamination of the laboratory area nor danger to personnel.

SUMMARY

The Problem

Studies of the fission process require rapid radiochemical separations of early-time fission products. To make measurements on these fission products as soon as possible after fission, it is desirable to have as short as possible the time required for the irradiation, transport of irradiated products to chemistry facilities, radiochemical separations, and physical measurements. An attempt is made in this work to reduce the time required to transport the irradiated products to the chemistry facilities.

Findings

An apparatus was constructed in which it is possible to have available, in about 2 seconds after irradiation, all of an irradiated solution in a form ready for radiochemical separations.

INTRODUCTION

In studies of short-lived radionuclides it is frequently necessary to recover irradiated samples from the site of irradiation and chemically process them as rapidly as possible. A system was developed which permits quantitative removal within about 2 seconds, of an irradiated solution from its irradiation and transporting container, called a "rabbit". The travel time of a rabbit transported by the pneumatic system from a reactor or an accelerator is 1 second or less. Therefore, chemical separations can be started within 3 seconds after irradiation. With this system purified samples of tin and of antimony were isolated from fission product mixtures in about ten seconds.* Such a system (see Fig. 4) has general utility in studies of short-lived radionuclides.

APPARATUS

Rabbit for Irradiating and Transporting Solution

The rabbit (Fig. 1) used is 0.725 in. diameter x 1-1/8 in. long and holds a volume of 1-1/2 ml. The body, one major part, of the rabbit is made of Teflon. This material is easy to machine, has a very low coefficient of friction, is inert to most reagents, holds up well in the neutron flux used (10^{10} n/cm²/sec), and does not become activated to the point where it is a radiological nuisance. Polyethylene could be used but it is more difficult to machine.

The cap was initially made of Teflon. However the threads did not hold their shape since Teflon tends to flow when under pressure for extended periods of time. Nylon was substituted for Teflon for it is tough and has many of Teflon's desirable properties. Since the cap does not come in contact with the solution, it need not be chemically inert.

The insert, a third major part, gives the contour for the efficient draining of the container. It is of polyethylene, which has the resilience necessary for a good seal and is inert to the chemicals currently used.

Two expendable diaphragms complete the rabbit. The one in contact with the solution is 0.016 in. thick Teflon, which gives strength to

*A. E. Greendale and D. L. Love, to be published.

the diaphragm and is chemically inert. The outer diaphragm of 0.020 in. thick gum rubber (rubber glove material) is needed to give a tight leak-proof seal around the needles used to withdraw samples.

Method of Removing Irradiated Solution From Rabbit

The arrangement of the hypodermic needles is shown in Fig. 2. The two 17-gauge stainless steel needles are silver soldered 1/8-in. on centers to a 1/16 in. thick 15/16 in. diameter brass plate.

One needle draws the solution out of the rabbit. It is positioned in the plate so the lower edge of the opening in the point of the needle is flush with the Teflon diaphragm of the rabbit. The lower end of this needle has a serrated portion for attaching polyethylene tubing (0.128 in. outside diameter, 0.085 in. inside diameter). The other needle lets air into the rabbit as the solution is withdrawn. The rinse solution (if one is desired) is also drawn through this needle into the rabbit. This needle is positioned in the plate so its tip is just below the top inside surface of the body of the rabbit.

The hub of the needle is threaded to fit a nut which pulls a tapered threaded adapter into the needle. The top of the adapter has a tapered 45° seat. A 3/32 in. diameter ground glass ball forms a check valve with this seat. (Ordinary boiling beads will not give a good fit). Two bypasses are milled inside of the hub so the ball will not seal the needle when it rises off of its seat. The check valve is necessary to prevent a small part of the solution from flowing out of this needle when it first enters the rabbit. The same size polyethylene tubing used for drawing the solution out of the rabbit is used for the air intake and rinse solution. The hole in the base of the adapter is tapered so the polyethylene tubing is held by friction. As the nut is screwed off of the threaded hub, it bears against a ring on the adapter, pushing the tapered adapter out of the needle hub. This ring also keeps the nut and adapter together so the nut will not be misplaced.

Apparatus for Catching Irradiated Rabbit

The "rabbit trap" (Fig. 3) is made up of five parts; the cylinder, cup, cap, retainer, and guide.

The cylinder is made of clear Lucite tubing, 1-5/16 in. inside diameter, 1-13/16 in. outside diameter and 6 in. long. The ends are threaded for 3/4 in. and are fitted with lock nuts.

The cup, made of brass, has two holes in the bottom through which the needles pass. A small locating pin goes into a hole in the brass plate holding the needles. This is to keep the needles from twisting when the cap is tightened. The cup has an O-ring on the inside to prevent the helium from the pneumatic system from leaking around and into the base of the rabbit. Four holes in the bottom edge of the cup allow any gas trapped below the rabbit to escape into the surge chamber in the cap. This gas in the cap cushions the rabbit when it comes to the end of its travel. There is also an O-ring seal between the cup and the plate holding the needles. The bottom of the cup is contoured to the shape of the base of the rabbit so the diaphragms will be supported when the rabbit comes to a stop. The cup screws into the threaded base of the next unit, called the retainer.

The retainer also is made of brass. It is fitted with four spring-loaded pawls which snap in behind and prevent the rabbit from bouncing away from the needles. Each pawl is cut to a slightly different length to allow for some variation in rabbit length. Vent holes in the retainer, placed in line with the top of the rabbit when seated in the cup, allow the helium to escape ahead of the rabbit. The escaping helium is used to trigger the shut-off valve of the pneumatic transfer system; consequently the outer edge of the retainer, which contacts the inside of the Lucite cylinder, is fluted to allow the helium to escape up the inside of the cylinder and out to the trigger.

The top of the retainer was originally tapered on the inside to take a 1.0 in. outside diameter Tygon tube, which runs to the reactor. This connection did not work very well since the junction between the soft plastic tubing and the retainer was difficult to adjust for proper alignment. A guide made of 3/4 in. inside diameter stainless steel of 0.020 in. wall thickness slips into a recess in the top of the retainer. The 3/4 in. inside diameter Tygon tubing slips over the top of and remains attached to the guide. To prevent misalignment of the plastic tubing and the guide when the Tygon tubing is under pressure (with resultant swelling of the tubing) a brass sleeve, which fits snugly around the Tygon, is soldered to the stainless steel guide. The top of the brass sleeve centers the guide in the Lucite cylinder. This section is fluted, as was the retainer, to allow the helium to escape between the guide and the inside of the Lucite tube.

Method of Adding Irradiated Solution to Chemical Analyzer

Figure 4 shows how the system is attached to the chemical apparatus for fast separations of fission products. The glass container pictured holds the carriers and other reagents needed in the chemical separation. Initially, the bottom stopcock is closed. The three-way stopcock

connecting the vessel to the vacuum and nitrogen is positioned for the vacuum. Just prior to the arrival of the "rabbit" from the reactor, the stopcock at the top of the vessel is opened. When the rabbit is impaled on the needles, the solution in the rabbit is drawn into the glass container within one second. A rinse can be performed in an additional second. The valve on the top of the container is then closed. The three-way valve is turned to shut off the vacuum and introduce nitrogen under a few pounds pressure. The valve on the bottom of the vessel can then be opened to send the solution to the next part of the separation apparatus which in this case is a semi-automatic chemical analyzer. It consists of a series of similar units for performing precipitations, solvent extractions, distillations, etc. which are placed in the proper sequence to make the required radiochemical separations.

SUMMARY

This system for transferring irradiated solutions from a rabbit to a piece of chemical apparatus has been found to be a marked improvement over anything presently available. The rabbit can be emptied within one second. One can make a quantitative transfer by using a rapid rinse (about one second). As the transfer is done in a closed system, there is no possibility of contamination of the laboratory area. Since the solutions are transferred quickly, the radiation dose absorbed by the laboratory worker is kept to a very low level. If one were to work at very high levels of radioactivity, the valves could be operated remotely by solenoids.

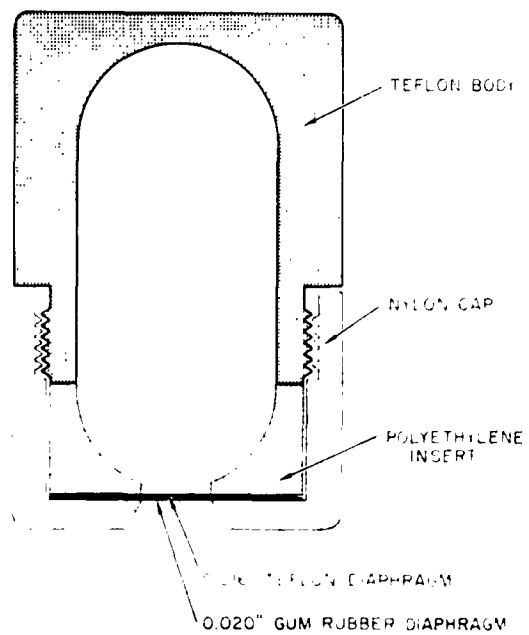


Fig. 1 Rabbit for Irradiating and Transporting Solution

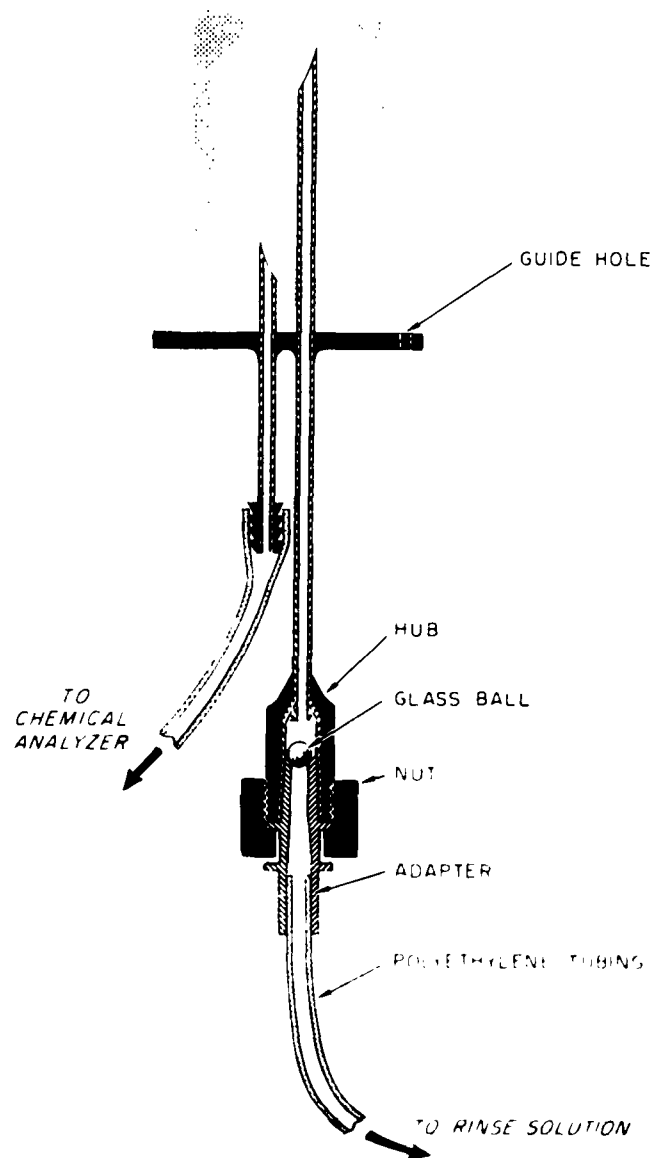


Fig. 2 Apparatus for Removing Irradiated Solution from Rabbit

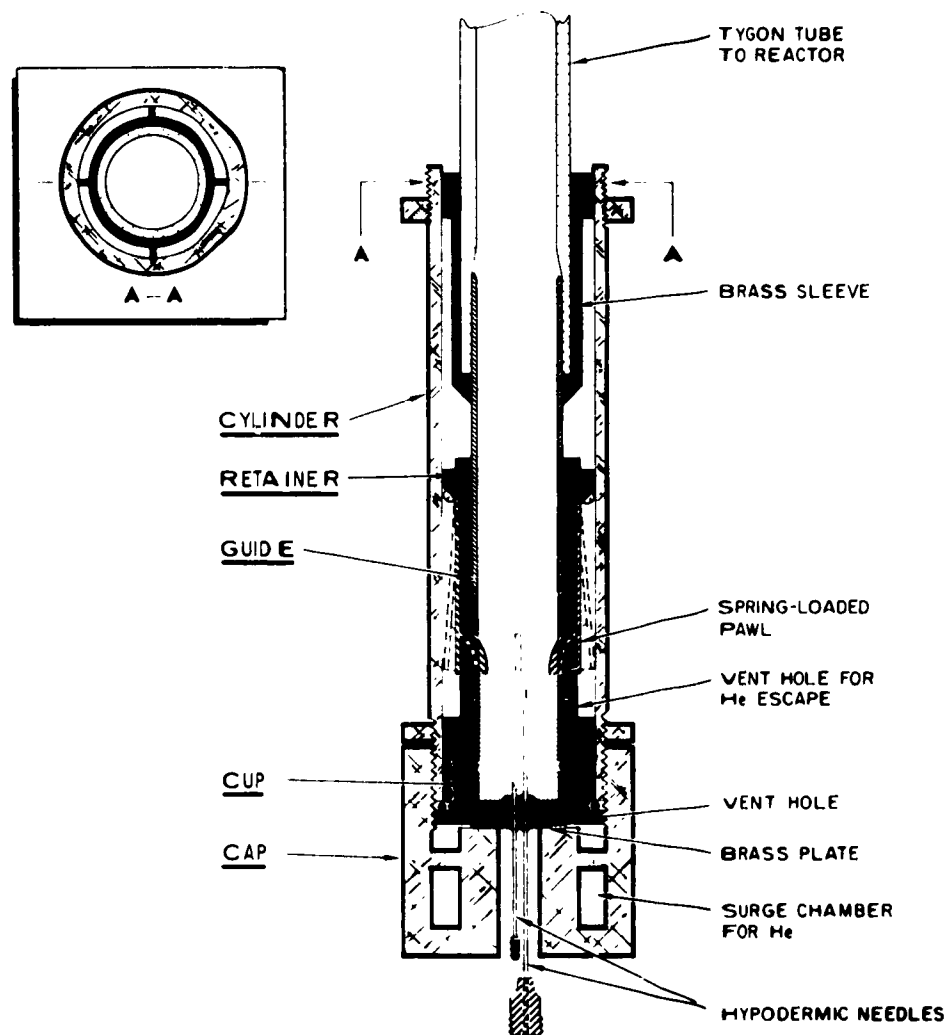


Fig. 3 Apparatus for Catching Rabbit

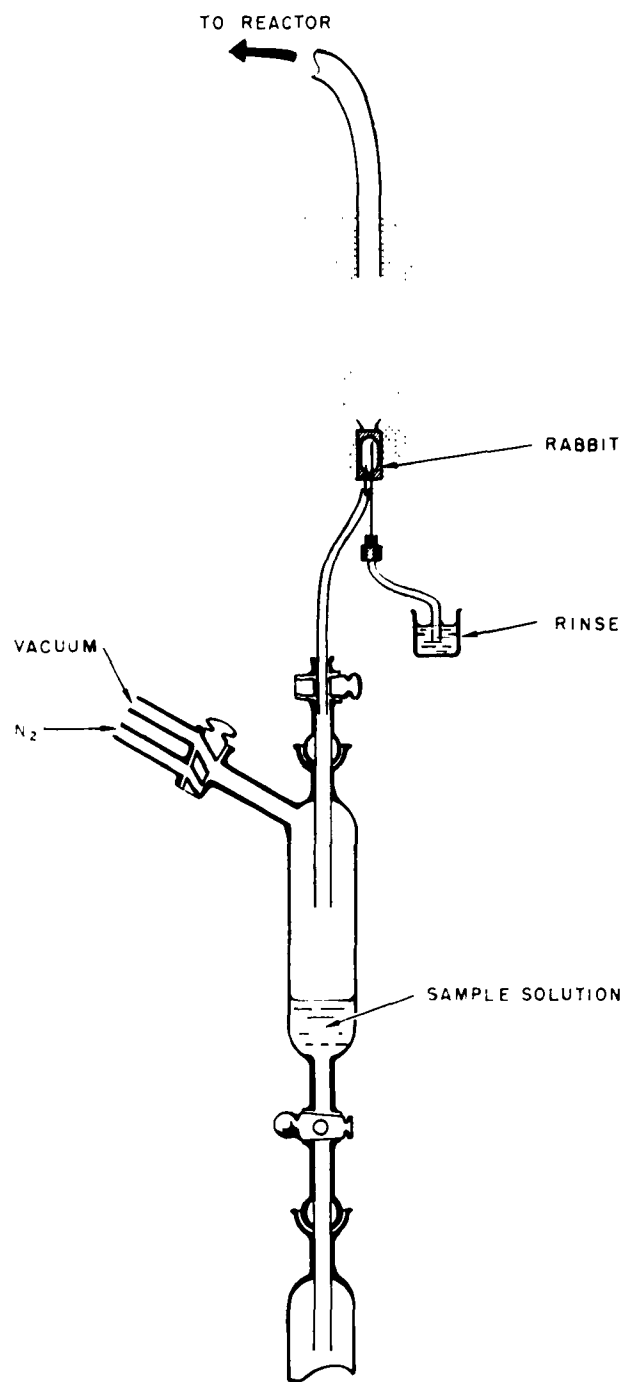


Fig. 4 Apparatus for Adding Irradiated Solution to Chemical Analyzer

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